

only open its squelch to copy a signal encoded with the CTCSS tone your radio is programmed to hear.

Terrestrial SSB/CW

SSB and CW operation is just as easy as FM. The IC-821H provides up to 45 W on CW and 35 W on SSB on 2 meters, and up to 40 W on CW and 30 W on SSB on 70 cm. RF output levels are continuously adjustable from a small pot on the front panel—yet another improvement over the IC-820H. With my dual-band attic beam antenna I was able to work quite a few stations on 2 meters and 70 cm. In fact, I even snagged a station about 300 miles away on 70 cm!

I found the IC-821H's receiver to be more than sensitive enough for my purposes on either band, but a preamplifier might be a nice addition. The IC-821H works with a number of receive preamps. There is a front-panel button that you can use to switch the preamp in or out of the line. It accomplishes this by switching 10 V on either the VHF or UHF antenna lines rather than a through a separate contact closure. Operators who prefer to switch the preamp with a separate contact

closure can do this via the SEND output on the rear-panel accessory socket.

It sounded as though ICOM was also using the '820H's effective noise blanker design in the '821H. I suffer from frequent pulse-type noise generated by my oil-fired furnace. The noise blanker worked wonders on this annoyance, making SSB and CW operation much more pleasant. The AGC switch (fast or slow) is located in the same row as the noise blanker.

Other bells and whistles on the IC-821H include a switchable RF attenuator. This is very handy for use with a too-hot preamplifier or microwave downconverter. You can switch in a speech compressor for weak-signal work, and an IF shift control is available for Main band receive.

If CW is your favorite mode, you'll be pleased to learn that the IC-821H includes a built-in iambic keyer. This feature came in handy for contacts through OSCAR 29, and will be particularly useful for Phase 3D. (We also installed the optional Main band 500-Hz CW filter; a separate, optional 500-Hz CW filter is available for the Sub band and satellite operation.)

Conclusions

ICOM has done an outstanding job of touching up the rough spots in the IC-820H. The result is a terrific dual-band multimode transceiver for all applications. Not only is the IC-821H an excellent VHF/UHF weak signal or contest radio, it is the cornerstone of a high-performance satellite station (digital or analog). Hams who have the Phase 3D satellite in mind will want to give serious consideration to the IC-821H. It also offers superb FM-voice and 9600-baud packet performance. Combine all of these features with the IC-821H's go-anywhere size and you have a radio that's ideal for almost any application above 144 MHz!

Manufacturer: ICOM America, 2380 116th Ave, Bellevue, WA 98004, tel 206-454-8155. Manufacturer's suggested retail prices: IC-821H transceiver, \$2040; PS-85 power supply, \$325; CT-17 level converter, \$135; UT-84 CTCSS tone squelch unit, \$88.

Order the IC-821H *Expanded Test Result Report* from the ARRL Technical Department, 225 Main St, Newington, CT 06111; \$7.50 for members and \$12.50 for nonmembers, postpaid. Credit card orders only may be placed by calling 860-594-0278.

QST Compares: Four High-Power Antenna Tuners

Okay, let's get something out of the way right up front: An antenna tuner does not *tune* your antenna, although it does tune your antenna system. An antenna tuner (also called an antenna coupler or trans-match) is a narrowband, variable-impedance transformer that presents your transmitter or amplifier with the proper load (typically 50 Ω). It will not make the antenna system on the other side of the tuner circuit radiate any better.

There are tradeoffs here, however. Under some circumstances, the antenna tuner itself (or its built-in balun) can eat up a significant part of the RF you'd like to have winging its way into the ether. Typically, this energy is dissipated instead as heat (as we confirmed during testing).

Not everyone needs an antenna tuner. You don't need one if you have a resonant antenna

(such as a coaxial-cable-fed single-band dipole) and the SWR is 2:1 or less at the frequencies you operate most often. While a tuner *can* help to reduce harmonics, it won't magically "clean up" your signal. While it is true that *some* antenna tuner configurations act as low-pass filters, it's unrealistic to expect the antenna tuner to cure problems it was never intended to fix.

We looked at four units that are touted as among the most rugged antenna tuners available. These units, designed to handle serious power, are marketed to hams who typically run maximum-power amplifiers for contesting and DXing and who have a demonstrated *need* for an antenna tuner. In these situations, antenna tuners often find their most frequent use on the lower bands—80 and 160 meters—where matching often can

be difficult. On the test bench for comparison are the MFJ-989C Versa Tuner V, the Nye-Viking MB-V-A (reviewed previously; see "Product Review," *QST*, Jun 1994), the Tucker T-3000 (Vectronics manufactured the T-3000 we tested. The T-3000 is no longer available, but the Vectronics HFT-1500 is very similar), and the N4XM XMatch, the most expensive amateur tuner on the market and the only one with a US patent (more on that later).

In addition to subjecting these units to "real-world" conditions, we conducted 10-minute "endurance" tests at several common load configurations at power levels in excess of 1000 W. In all cases, we power tested the units on 160, 20 and 10 meters at 1250 to 1500 W (depending on the band), using a 40% duty cycle (40 ms on, 60 ms off) to simulate

Table 2
Maximum-power Antenna Tuners—Features:

	MFJ MFJ-989C	Nye-Viking MB-V-A	Tucker T-3000	N4XM XMatch
Circuit type	T-network	Pi-network	T-network	T-network
SWR/wattmeter	Yes	Yes	Yes	No
Switch to select different antennas for tuning	Yes	Yes	Yes	No
Balun type	1:1 current	1:1 voltage	4:1 voltage	No balun
Dummy load	Yes	No	No	No
"Mark-on" front panel to record settings	No	No	Yes	Yes
Manufacturer's PEP rating (matching range)	1500 W (35-500 Ω)	3000 W (40-2000 Ω)	2000 W (range not specified)	1500 W*
Physical dimensions (HWD) in inches	5x10.6x15.1	6.7x14.6x12.2	5.9x12.6x11.5	5.6x14x14.4
Manufacturer's suggested retail price	\$350	\$830	\$349	\$1045
Typical selling price as of Jan 1997†	\$298	\$746	\$‡	\$1045*

*See text for details.

†Typical selling prices represent an average of street prices obtained from three equipment retailers, exclusive of any sales, coupons or rebates.

‡The T-3000 is no longer available. The similar Vectronics HFT-1500 typically sells for \$380.

▲ The XMatch is only available from the manufacturer.

conversational CW. Not all of the units fared well, and under some not-so-extreme conditions, the inductors of some tuners got quite hot (*some* heating is normal). Remember, heating in the tuner is equivalent to loss in power.

They all did much better when used in a much more typical matching situation: covering the 80 and 75-meter bands while using a center-fed, 80-meter dipole (cut for 3750 kHz) and fed with RG-8 coaxial cable. In this case, we were able to obtain a match with each of the review tuners on each end of the band. We also checked the accuracy of any built-in wattmeters against laboratory-quality instruments, looked for imbalance in any built-in baluns,¹ and tested for insertion loss in the bypass mode on 160, 20 and 10 meters. All tuners showed negligible insertion loss in the bypass mode (0.1 dB or less).

Our special thanks to Frank Witt, AI1H, author of "How to Evaluate Your Antenna Tuner"—*Parts 1 and 2* (*QST*, Apr 1995, pp 30-34; May 1995, pp 33-37), who graciously agreed to test each unit for power loss, SWR bandwidth and imbalance (for units with internal baluns) using his geometric resistance boxes and an MFJ-259 antenna analyzer.² Also, many thanks to Mike Gruber, W1DG, of the ARRL Lab, who spent many hours testing these units, and to Dean Straw, N6BV; Glenn Swanson, KB1GW; and Rick Lindquist, N1RL, for their assistance in preparing this review.

Tables 3, 4, 5 and 6 show how each tuner fared, but a word of caution: These tables represent the results of testing at low power. They do not necessarily reflect how each tuner will perform at maximum specified power—although our power ("endurance") testing should give you some idea.

THE MFJ-989C VERSA TUNER V

The Versa Tuner V—MFJ's biggest and best—is somewhat revised from an earlier unit that carried the same model number. The newer tuner has an *airwound* rotary inductor instead of the plastic-form inductor on the earlier tuner. Perhaps the most notable physical feature of the MFJ-989C is its shape. The width is just about right, but the unit is some 15 inches deep—not counting the rear-panel binding posts—so finding a suitable place for it on your shack table could be a challenge. The MFJ-989C comes in a black vinyl-clad clamshell metal enclosure.

This tuner features five front-panel controls, including a switch to select one of two antennas for tuning or to bypass the unit to either of the two antennas. For tuning purposes, there are three controls: **TRANSMITTER**, **ANTENNA** and **INDUCTOR**. The **TRANSMITTER** and **ANTENNA** controls are pointer knobs that directly drive the variable capacitors in the box. Each has a 0-10 scale.

The **INDUCTOR** control has a crank on it; a digital counter reads out the relative position of the roller for future reference (it's not a true "turns counter"). It takes 19 full turns

to go from one end of the inductor to the other. A lighted cross-needle SWR/wattmeter is between the **ANTENNA** and **INDUCTOR** controls on the front panel. In the ARRL Lab, wattmeter error on both scales was within 10% on 160, 20 and 10 meters. You need to supply 12 V dc to the rear panel to light the meter. A **PEAK** or **AVG POWER** button lets you make the meter a peak-reading or average-power type. A **POWER** switch selects a 2000 or 200-W range for the meter. An **ANTENNA SELECTOR** switch lets you pick one of two antennas connected to rear-panel coaxial connectors (direct or via the tuner), a single-wire or balanced-feed-line antenna, or a 50-Ω internal dummy load. This switch is in very close proximity to the **TRANSMITTER** and **ANTENNA** controls (less than 1 inch), so it's easy to inadvertently nudge one of the tuning controls off its setting while using the switch.

Inside, in addition to the tuning capacitors

(240 pF each, ceramic-insulated) and the airwound rotary inductor (we estimated its value to be in the vicinity of 28 to 30 μ H), you'll find the metering circuitry, a 1:1 current-type balun and a dummy load. The MFJ is the only tuner to include a dummy load, which, in this case, appears to be a 90-W non-inductive resistor. This should be adequate for short-term tuning of your *exciter*, but unless you enjoy the smell of smoke, we'd advise against firing up your legal-limit amp into that load for more than a few seconds—and that would be pushing it. The balun consists of 11 bifilar turns of Teflon-insulated, stranded #16 wire around two 2.5-inch powdered-iron toroids. The rear panel features four, husky ceramic insulators (with handy wing nuts) to connect balanced or single-wire feeders.

The rotary inductor includes an arrangement that automatically shorts out approximately half of the turns in the coil when you roll beyond a certain point. MFJ says this device eliminates a detrimental series resonance point on the higher bands by moving it above the operating frequency. The **ANTENNA SELECTOR** switch is a ceramic-insulated wafer type.

The 10-page *Instruction Manual* includes a chart that provides reasonable starting points for tuning, and hints on how to get the most from the tuner. One useful table gives best and worst-possible open-wire feed-line lengths for various dipole antennas.

Testing in the unbalanced configuration,



Table 3
MFJ Versa Tuner V Model MFJ-989C

SWR	Load (Ω)		Unbalanced					Balanced				
			160	80	40	20	10	160	80	40	20	10
16:1	3.125	% Pwr Loss 1.5-SWR BW Imbalance	80 1	60 1	24 1	20 2	22 2	77 1	31 1	34 2	2 0.4	
8:1	6.25	% Pwr Loss 1.5-SWR BW Imbalance	58 1	38 1	15 2	12 4	12 4	77 1	31 1	25 3		
4:1	12.5	% Pwr Loss 1.5-SWR BW Imbalance	38 1	22 2	4			46 1	22 2	17 3		22 2
2:1	25	% Pwr Loss 1.5-SWR BW Imbalance	29 2	16 3				31 2	17 3	12		17 4
1:1	50	% Pwr Loss 1.5-SWR BW Imbalance	20 3					21 3				
2:1	100	% Pwr Loss 1.5-SWR BW Imbalance	18 3	11				22 3	11			
4:1	200	% Pwr Loss 1.5-SWR BW Imbalance	20 3					22 3 0.3	11			
8:1	400	% Pwr Loss 1.5-SWR BW Imbalance	22 4				11	22 4 0.8	0.7	0.7		
16:1	800	% Pwr Loss 1.5-SWR BW Imbalance	22 4			4	18 3	24 4 1.2	1.3	1.8	14 3 1.8	11 4 1.6

Key:

1. Unshaded boxes represent the tuner's best performance capabilities. An empty, unshaded box means power loss was 10% or less, the 1.5-SWR bandwidth was 5% or greater (the lower this number, the more sensitive the tuning), and the imbalance was 0.2 or less (equivalent to 14 dB of common-mode rejection for current baluns).
2. A light-shaded box means power loss exceeded 21% (ie, 1 dB) or imbalance exceeded 0.4.
3. A dark-shaded box means that a 1:1 SWR could not be obtained.
4. The 1.5-SWR bandwidth (SWR BW) represents a percentage of operating frequency.
5. The imbalance number is a ratio of common-mode current to differential current when the center tap of the balanced load is grounded.

¹Notes appear on page 77.

we found that loss on 160 meters was high, especially for low-impedance loads (ie, 8:1 SWR or higher), where it was 58% or more, and to a lesser extent on 80 meters. In the balanced configuration, the balun didn't contribute significantly to increased power loss or tuning sensitivity on 80 and 160 meters, but the tuner's low-loss tuning range was reduced on the other bands. Imbalance data reveal that the balun's winding impedance is low on 40, 80 and 160 meters. On these bands, imbalance is well above our arbitrary 0.2 limit (equivalent to 14 dB of common-mode rejection) for loads above 200Ω (see table 3).

During high-power testing, the inductor in the MFJ-989C got very hot at a power level of slightly more than 600 W while attempting to match a 12.5Ω load (4:1 SWR) on 160 meters (admittedly a difficult situation). We contacted the manufacturer when the coil also got quite hot at 750 W while attempting to match a 50Ω load (1:1 SWR). MFJ suggested that 750 to 800 W would be the maximum limit to continue the testing on 160 meters. We experienced no similar problems on 20 or 10 meters.

Manufacturer: MFJ Enterprises Inc., PO Box 494, Mississippi State, MS 39762; tel 601-323-5869; fax 601-323-6551; Manufacturer's suggested retail price, \$350.

NYE-VIKING MB-V-A

The MB-V-A (pronounced MB-five-A) is a classically handsome, sizable box that looks like it means serious business, while also offering a nice range of features. The MB-V-A is the only pi-network type coupler among the present tuners.

The two huge calibrated dials on the front panel are the MB-V-A's most prominent features. The **INDUCTOR** dial—which features a little crank affixed to the knob—is attached to a 25:1 vernier, and it's a true turns counter. The dial plate reads 0-25. The rotary inductor is a $23\mu H$ airwound coil. The right-hand knob, which has 0-100 calibrations in either direction, directly controls a large, dual-section capacitor on the output side of the pi-section circuit (the input side of the pi-section consists of a fixed, 230 pF capacitor). On our unit, turning this knob produced a harsh, scraping metal-to-metal sound. We determined it came from a slip-ring connector on the capacitor.

Four push-button switch actuators—plain, white plastic shafts, actually—are located between the two knobs. These switches let you switch in additional values of capaci-

tance. The 70-pF section of the dual-section variable capacitor is in the line at all times; pushing switch 2 adds a 160-pF section in parallel. Switches 3, 4 and 5 each add 195 pF additional capacitance. Five other similar-looking push-button type actuators above the first set let you select the antenna to be tuned or bypass the tuner circuitry altogether. The spring-loaded switches behind these actuators require substantial force to activate, so it's not likely you'll accidentally "bump" one in while using this tuner.

The MB-V-A features separate panel meters for indicating SWR and RF watts (0-300 scale). An internal 9-V battery powers the metering circuitry. The meters may be lighted from an external 12-V power source, and an unlabeled front-panel toggle switch lets you turn off the meter illumination. In the ARRL Lab, we measured wattmeter error on both scales at 10% or less on 160, 20 and 10 meters. The same tuner is available without the SWR/wattmeter circuitry. The heavy-gauge aluminum clamshell enclosure has a black matte finish.

Peering inside, the most remarkable thing you might notice is that most of the components—including the huge, dual-section variable capacitor—have been custom-made just for this tuner. In fact, these tuners are built by hand, individually. The business ends of the switches use large, silver-plated bus bars and contacts. The capacitor has $\frac{3}{8}$ -inch plate spacing, and the various fixed 195-pF capacitors have been manufactured "sandwich

style" with metal plates and a high-voltage dielectric (they're said to be rated at 15 kV). The 25-turn inductor uses copper-ribbon (ie, "flat") windings, and the contactor wheel rides on the inside edge of the turns. The coil is silver-plated. A trifilar, six-turn, triple-toroid-core 1:1 voltage balun (patriotically wound using red, white and blue-insulated #12 stranded wire) is available for using a balanced feed line. Oddly, one winding of the balun is always in the circuit. You can connect a balanced feed line or single-wire feeder to the appropriate ceramic-insulated binding posts on the rear panel. You'll need a small wrench or pliers, however, as the unit does not have wing nuts or thumbscrews.

The compact, nine-page *Instruction Manual* contains hook-up and operational details, a schematic of the unit and a chart to log settings for each band. The manual warns several times against "hot switching" the antenna or capacitance switches, and wisely recommends tuning up at low power.

As we had discovered in our first review of this tuner, the MB-V-A does not like 10 meters very much; it was quite lossy across the band. For folks with beams (and no need for a tuner), this won't be much of a drawback, since it worked pretty well almost everywhere else in the unbalanced configuration, with the exception of low-impedance loads (ie, 8:1 SWR or higher) on 160 and 80 meters and high-impedance loads on 160 meters (see Table 4). In fact, the manual states that the MB-V-A has "limited coverage" of

Table 4
Nye-Viking MB-V-A

SWR	Load (Ω)		Unbalanced					Balanced					
			160	80	40	20	10	160	80	40	20	10	
16:1	3.125	% Pwr Loss 1.5-SWR BW Imbalance			22	22	67			31	35	69	
					2	1				2	1	1	
8:1	6.25	% Pwr Loss 1.5-SWR BW Imbalance			14	12	48			19	25	46	
					3	1				4	2	1	
4:1	12.5	% Pwr Loss 1.5-SWR BW Imbalance					35			19	30	40	
							1				3	1	
2:1	25	% Pwr Loss 1.5-SWR BW Imbalance						26			14	21	35
								1					1
1:1	50	% Pwr Loss 1.5-SWR BW Imbalance						24				15	26
								1					1
2:1	100	% Pwr Loss 1.5-SWR BW Imbalance						22				11	22
								1					1
4:1	200	% Pwr Loss 1.5-SWR BW Imbalance						22					26
								1					2
8:1	400	% Pwr Loss 1.5-SWR BW Imbalance					11	31					27
					4	4		1					2
16:1	800	% Pwr Loss 1.5-SWR BW Imbalance						40					31
													2

Key:

1. Unshaded boxes represent the tuner's best performance capabilities. An empty, unshaded box means power loss was 10% or less, the 1.5-SWR bandwidth was 5% or greater (the lower this number, the more sensitive the tuning), and the imbalance was 0.2 or less (equivalent to 14 dB of common-mode rejection for current baluns).
2. A light-shaded box means power loss exceeded 21% (ie, 1 dB) or imbalance exceeded 0.4.
3. A dark-shaded box means that a 1:1 SWR could not be obtained.
4. The 1.5-SWR bandwidth (SWR BW) represents a percentage of operating frequency.
5. The imbalance number is a ratio of common-mode current to differential current when the center tap of the balanced load is grounded.



160 meters. For balanced configurations, the internal balun reduced the low-loss tuning range. In addition to the same high-loss problems on 10 meters, the unit was even less forgiving of low-impedance loads on 160 and 80 meters when the balun was used. It appeared that having the balun winding always in the circuit contributed to high loss and "sensitive" tuning on 10 meters (taking it out of the circuit reduced losses on 10 meters for low-impedance loads). Also, it seemed that the presence of the large fixed capacitor on the input side might have contributed to overly sensitive tuning on 10 meters.

During high-power testing, the inductor only got warm on 160 and 20 meters with a 50Ω load (1:1 SWR), and handled the maximum power (1300-1500 W) without incident. On 10 meters, however, the inductor became very hot while running slightly more than 1000 W and attempting to match either a 12.5Ω or a 50Ω load.

Manufacturer: Wm. M. Nye Company Inc. Box 1877, 1427 Shannon Ln., Priest River, ID 83856; tel 208-448-1762; fax 208-448-1832. Manufacturer's suggested retail price, \$830. Model MB-V-B (without metering circuitry), \$689.

TUCKER T-3000

The Tucker T-3000 is a modest-size tuner that features a **T** network. Vectronics manufactured this tuner for Tucker, which sold its Amateur Radio inventories to Ham Radio Outlet last fall. As this review went to press, we learned that HRO has sold out its supply of the T-3000, which is very nearly the same tuner as the Vectronics HFT-1500, except that the current production HFT-1500 has an airwound inductor instead of the Delrin-body coil like the one in the T-3000. The airwound inductor should be an improvement, but we didn't test the HFT-1500.

The T-3000 front panel is nicely laid-out and offers vernier-driven **ANTENNA** and **INPUT** capacitors on either side of the **INDUCTOR** hand crank and counter. The red pointer on each capacitor tuning assembly covers a 0-10 logging scale. The counter for the inductor is a real turns counter; it takes 41 turns of the handle—one for each turn—to go from one end to the other. A cross-needle meter displays both SWR and power. In the ARRL Lab, we measured wattmeter error on both scales at 21% or less (15% on the low-power scale) on 160, 20 and 10 meters. It was worst on 10 meters. A 21-segment LED bar graph indicates PEP (the last segment is red). It has

separate push-button controls to set **LEVEL** and **DELAY** time. Another button sets the metering range (3 kW or 300 W), and a fourth turns the **LAMP** on or off. A rotary selector below the SWR/wattmeter lets you select one of two coaxial antenna feed lines, or a single wire/balanced feed line (depending on what's hooked up at the rear panel)—or you can bypass the tuner circuitry altogether.

The attractive gray finished aluminum clamshell case opens by removing four screws. Inside, you'll find that lots of the box is taken up with the metering and LED circuitry. You'll also see a couple of modest-size variable capacitors with ceramic insulation. The 41-turn, 28- μ H inductor is built on a Delrin plastic form. The 4:1 voltage balun consists of 11 bifilar turns of #14 stranded wire on an insulated double-toroid core. The rotary selector switch has ceramic wafers and silver-plated contacts, but it could not be described as "heavy-duty."

To connect a balanced feed line, the tuner has three Delrin-insulated binding posts on the rear panel. You'll need a small wrench or pliers, however, as the unit does not have wing nuts or thumbscrews.

In the unbalanced mode, the Tucker T-3000 was lossy or unable to achieve an acceptable match on all bands when faced with a low-impedance load—especially on 80 and 160 meters. Tuning also was very sensi-

tive on 160 meters. The situation got much worse in the balanced mode, where power losses ranged from 35% to an astonishing 99% across 160 meters and 60% or higher on 80 meters for low-impedance loads (ie, 8:1 SWR or higher). We found the internal 4:1 voltage balun was lossy for all 80 and 160-meter loads and tuning was touchy on both low bands. Testing indicated that the balun lacks balance quality on the higher-frequency bands for low-impedance loads, especially on 10 meters (see Table 5). We'd suggest using a high-quality external balun with this tuner instead.

During high-power testing, while attempting to match a 50Ω load on 160 meters, the T-3000 arced internally when we reached a power level of 1300 W (which exceeds the manufacturer's single-tone specification of 1000 W), so we dropped back to 1220 W. There were no visible signs of burning or smoke, but the coil backplate was hot. After it was allowed to cool, the unit worked OK at lower power levels. The tuner also arced at 600 W while trying to match a 12.5Ω load on 160 meters, so we dropped the power to 500 W and continued the test. The coil got warm, but the tuner worked for the full 10 minutes. On 20 and 10 meters at 1250 to 1500 W, the tuner got warm during the 10-minute test, but it performed well.

Manufacturer: The Tucker T-3000 is no

Table 5
Tucker T-3000

SWR	Load (Ω)		Unbalanced					Load* (Ω)	Balanced				
			160	80	40	20	10		160	80	40	20	10
16:1	3.125	% Pwr Loss 1.5-SWR BW Imbalance			43 2	43 4	29 2	12.5	76 1	80 2	38 1	34 2	38 6
8:1	6.25	% Pwr Loss 1.5-SWR BW Imbalance			22 2	27 4	20 4	25	61 1	60 2	27 1	24 3	29 7
4:1	12.5	% Pwr Loss 1.5-SWR BW Imbalance	38 1	24 2	16 4	20	14	50	40 1	26 2	15 4	20 0.4	20 0.8
2:1	25	% Pwr Loss 1.5-SWR BW Imbalance	26 2	18 3	17	11	13	100	35 1	22 3		12 1	13 1.6
1:1	50	% Pwr Loss 1.5-SWR BW Imbalance	13 3	11		11		200	35 1	13 4			0.6
2:1	100	% Pwr Loss 1.5-SWR BW Imbalance	17 3	11				400	40 1	22 3			
4:1	200	% Pwr Loss 1.5-SWR BW Imbalance	14 3					800	61 1	22 2			13
8:1	400	% Pwr Loss 1.5-SWR BW Imbalance					14	1600	98 1	29 2	16	12	22
16:1	800	% Pwr Loss 1.5-SWR BW Imbalance				11	22 2	3200	99 1	35 1		15 4	26 3

*Because this unit used a 4:1 voltage-type balun, load values for the balanced configuration are four times the unbalanced values.

Key:

1. Unshaded boxes represent the tuner's best performance capabilities. An empty, unshaded box means power loss was 10% or less, the 1.5-SWR bandwidth was 5% or greater (the lower this number, the more sensitive the tuning), and the imbalance was 0.2 or less (equivalent to 14 dB of common-mode rejection for current baluns).
2. A light-shaded box means power loss exceeded 21% (ie, 1 dB) or imbalance exceeded 0.4.
3. A dark-shaded box means that a 1:1 SWR could not be obtained.
4. The 1.5-SWR bandwidth (SWR BW) represents a percentage of operating frequency.
5. The imbalance number is a ratio of common-mode current to differential current when the center tap of the balanced load is grounded.



longer manufactured. Our review unit was built by Vectronics, now in the MFJ family. Vectronics offers the similar HFT-1500 (manufacturer's list price, \$460). Vectronics, 1007 Hwy 25 S, Starkville, MS 39759; tel, 800-363-2922; fax 601-323-6551.

N4XM XMATCH

Paul D. Schrader, N4XM, calls his XMatch antenna tuner a "classic lowbander." The unit is aimed at the no-nonsense, discriminating contestor or DXer who doesn't mind plunking down big bucks for a station accessory of demonstrated quality. With no bells or whistles—not even an SWR meter or a switch to select another antenna for tuning—the XMatch is focused on doing one job well, providing a match between your transmitter or linear and the antenna system with as little loss as possible. The XMatch has no balun; this tuner is designed only for unbalanced loads. Schrader constructs each unit personally, one at a time. That's one reason why you pay up front when you order, and also why prospective owners require patience. The XMatch is available only from Schrader, a registered professional engineer and active amateur. Despite the price tag on the XMatch, Schrader offers "no guarantee or warranty of any kind" for the XMatch.

The XMatch box is imposing. It's also nearly as long as the MFJ-989C, so it has a substantial footprint. On the left-hand side of the front panel is a hand-cranked rotary **INDUCTOR** dial—with a real turns counter—for the rotary inductor. The **CAPACITOR** dial on the right-hand side is direct drive and has a 0-100 scale. A rotary switch in between lets you select two operating modes, **XM1** and **XM2** (more on these later), **DIRECT**, **AUX** (to connect to another antenna or device, such as a dummy load, while bypassing the tuner) and **OFF**.

Removing the cover means backing out six Philips head machine screws and associated hardware. In doing so, you'll notice that the top half of the case is isolated from the bottom half by the use of insulated washers—except at one screw, where a star washer is used to insure a good electrical connection (assuming the screw has been tightened).

The XMatch is a variation on the T-network design (although Schrader says he does not consider it a T-network but a unique design). Inside, there's a huge dual-section Cardwell capacitor (24-291 pF per section), a very heavy-duty switch and a 38-turn Cardwell ceramic-body rotary inductor (28 μ H) coupled to the turns counter on the front

panel. The second capacitor in the T circuit is comprised of five 100-pF and one 75-pF, 5-kV capacitors (575 pF, total) sandwiched between (and connected electrically to) aluminum plates. In the **XM1** switch position, the variable capacitor is on the input side of the T, while the fixed capacitor is on the output side; in the **XM2** switch position, the fixed capacitor is on the input side while the variable capacitor is on the output side. This feature and the switch's associated abilities to bypass the tuner altogether and/or to ground the input and output are the essence of Schrader's US Patent 4,763,087—a fixed capacitance on one side of the network and a variable capacitor on the other, with provisions to swap their relative positions within the network. (Schrader's patent covers use of this concept for both T-type and pi-type matching networks.)

The rear panel—which bears a large *Warning! High Voltage* label that includes the unit's US, Canadian and UK patent numbers—has three SO-239 connectors for **INPUT**, **ANT** and **AUX** and a ground connector.

The literature that comes with the XMatch explains that the XMatch is a "low-band optimized" tuner that can handle "full legal power without arc-over" within these SWR "circles": 5:1 from 1.8 to 3.5 MHz, 7:1 from 3.5 to 21.45 MHz, and 4:1 from 21.45 to 29.7 MHz.

During testing, the XMatch went where others feared to tread. The worst power loss we encountered was 27% while confronting a 3.125Ω load (16:1 SWR) on 160 meters. We also were unable to obtain acceptable matches at 3.125Ω on 20 meters or at SWRs greater than 4:1 (both hi-impedance and low-impedance) on 10 meters. But we should emphasize that all of these are extreme matching situations that exceed realistic expectations

as well as the manufacturer's specifications. We also found that tuning was sensitive for some low-impedance situations on 160 and 80 meters. Otherwise, the XMatch gives you a huge playing field in terms of its matching capabilities (see Table 6).

In the high-power testing, the XMatch inductor only got warm when tuned to match a 12.5Ω load (4:1 SWR) on 160 meters while running 1320 W, but it worked fine. On 20 meters, 1500 W of power didn't faze the unit. The inductor ran cool for the entire test, while on 10 meters it ran cool on most loads.

Manufacturer: Paul D. Schrader, N4XM, 7001 Briscoe Ln, Louisville, KY 40228-1653; tel 502-239-2043. Manufacturer's suggested retail price, \$1045. (N4XM also offers other tuner models, two of which include vacuum variables. Contact him directly for details.)

Notes

¹For a description of imbalance as a measure of balun quality, see "Baluns in the Real (and Complex) world," by Frank Witt, AI1H, *ARRL Antenna Compendium*, Vol 5.

²The geometric test boxes presented pure resistive loads, even though a more comprehensive (and much more time-consuming) test would have included complex-impedance loads—possibly at specified power ratings. For example, a load of $40 \pm 30\Omega$ would yield a 2:1 SWR, and a possible variation in tuner performance from the purely resistive 2:1 load shown in our tables. For most situations, however, an antenna tuner may be satisfactorily characterized using only resistive loads. Geometric resistance boxes are available from Frank Witt, AI1H, 20 Chatham Rd, Andover, MA 01810-5772 (please enclose an sase); e-mail fjw@world.std.com.

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Table 6
N4XM XMatch

SWR	Load (Ω)		Unbalanced				
			160	80	40	20	10
16:1	3.125	% Pwr Loss 1.5-SWR BW	27 1	18 2	11 3		
8:1	6.25	% Pwr Loss 1.5-SWR BW	17 1	11 3			11
4:1	12.5	% Pwr Loss 1.5-SWR BW					
2:1	25	% Pwr Loss 1.5-SWR BW	4				
1:1	50	% Pwr Loss 1.5-SWR BW					
2:1	100	% Pwr Loss 1.5-SWR BW					
4:1	200	% Pwr Loss 1.5-SWR BW					
8:1	400	% Pwr Loss 1.5-SWR BW					
16:1	800	% Pwr Loss 1.5-SWR BW				4	

Key:

1. Unshaded boxes represent the tuner's best performance capabilities. An empty, unshaded box means power loss was 10% or less and the 1.5-SWR bandwidth was 5% or greater (the lower this number, the more sensitive the tuning).
2. A light-shaded box means power loss exceeded 21% (ie, 1 dB).
3. A dark-shaded box means that a 1:1 SWR could not be obtained.
4. The 1.5-SWR bandwidth (SWR BW) represents a percentage of operating frequency.

